Surface and Overlayer Electronic Structure of Wide Band Gap Nitride Semiconductors

Kevin E. Smith, Boston University, DMR- 9986099

The goal of this program is to measure the electronic structure of thin film wide band gap nitride semiconductors and to understand how this structure effects the growth of these nitride films, the growth of contact overlayers on the nitrides, and the chemical stability of the films and overlayers. These materials have numerous potential applications in optoelectronic and high temperature devices. Despite much study over the last decade, much remains unknown about their fundamental physical properties.

A highlight of our 2001/2002 program was the first comprehensive study of the electronic structure of $In_XGa_{1-x}N$. High resolution soft x-ray emission (SXE) and soft x-ray absorption (SXA) spectroscopies were used to measure the valence and conduction band densities of states across a wide range of $In_XGa_{1-x}N$ alloys. Experiments were performed at the National Synchrotron Light Source (NSLS), Brookhaven National Laboratory. Figure 1(a) shows a series of SXE and SXA spectra from thin film $In_XGa_{1-x}N$. The non-linear evolution of the band gap as a function of In content is clearly visible in the spectra. This evolution is plotted in Fig. 1(b). Due to strong dipole selection rules and the low probability of interatomic decay, SXE is very sensitive to the existence of hybrid states. Fig. 2 shows for the first time the emission from N *2p* states hybridized with the Ga *3d* and In *4d* shallow core levels. For more details, please see Phys. Rev. B **65**, 5201 (2002).

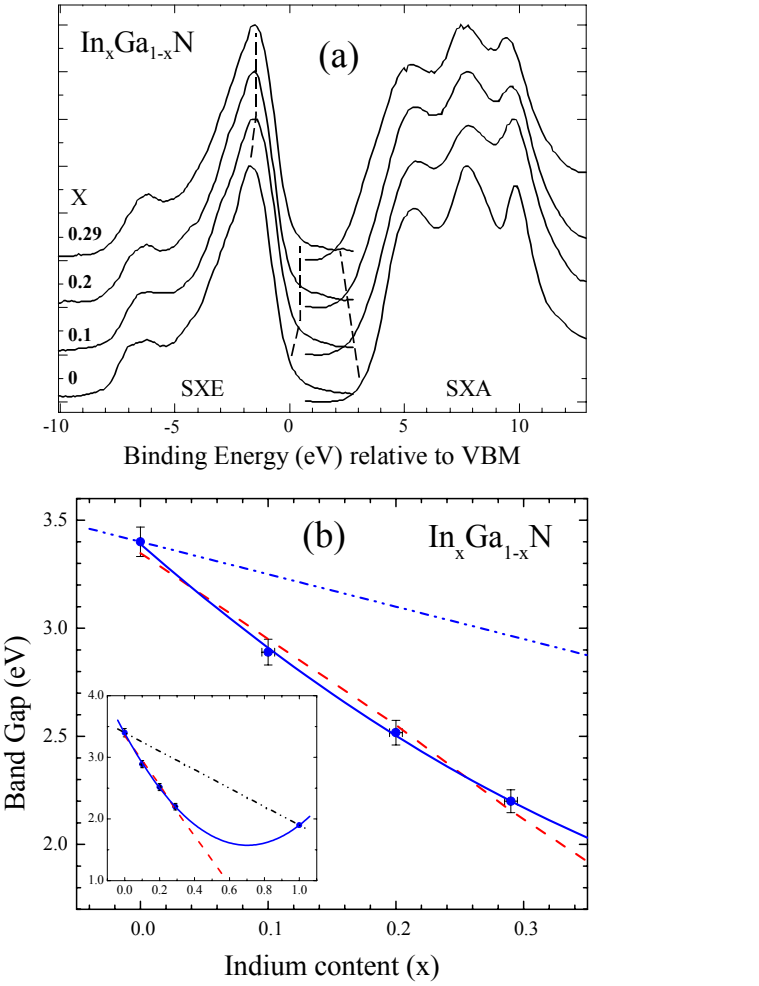

Figure 1: (a) SXE and SXA spectra from $In_XGa_{1-x}N$; (b) evolution of the band gap as a function of In content.

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Educational Activities:
This program involves one undergraduate student (Paul Sheridan), two graduate students (Philip Ryan and James Downes) and one postdoctoral research associate (Dr. Cormac McGuinness). *Note also that the PI serves as the Academic Director of the newly formed Center for Excellence in Teaching at Boston University.*

Infrastructure Impact:
The PI successfully used the present NSF award to leverage significant funds for scientific infrastructure enhancement. Last year he was awarded $220,000 from the Defense University Research Instrumentation Program of the Army Research Office to construct a multi-technique spectrometer system that will be used in this NSF program. Construction of the new system is almost finished, and it features both a high resolution angle resolved photoemission spectrometer (100 mm Scienta), and our novel high resolution soft x-ray emission spectrometer that was used to make the measurements presented in Figs. 1 and 2.

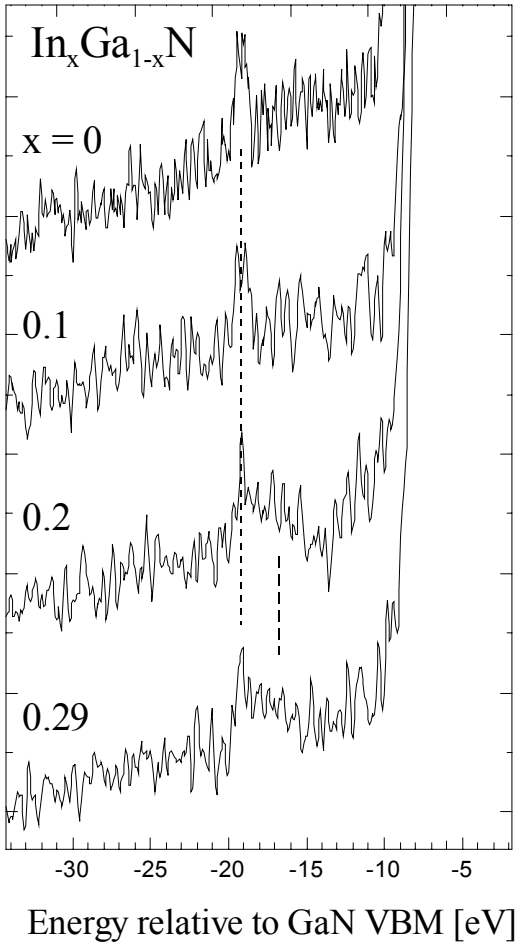

Figure 2: Emission from N *2p* states hybridized with Ga *3d* and In *4d* shallow core level states as a function of In content.